 ISSN 2278 - 1587

DIVERSITY, POPULATION AND HABITAT USED BY SPIDERS IN BANANA AGRO-ECOSYSTEM

Seema Keswani and Ganesh Vankhede
Department of Zoology, S.G.B.Amravati University, Amravati-444602
keswaniseema10@gmail.com; vganeshan2001@rediffmail.com

ABSTRACT

50 species from 39 genera and 15 families were recorded from Banana agro-ecosystem. By using visual search method and pitfall trap method in all 11880 spider specimens were collected per acre which includes 5792 (48.75%) females, 2696 (22.69%) male and 3392 (28.55%) immature individuals. Araneids dominated the collection with 3416 (28.75%) specimens per acre followed by Lycosids 3208 (27.00%), Sparassids 1688 (14.20%) and then Salticids 1200 (10.10%). The species abundance was in the order Araneidae > Salticidae > Lycosidae > Sparassidae. 15 new species were recorded from Banana agroecosystem which includes *Cyclosa purnai* sp. nov., *Clubiona foliata* sp. nov., *Pardosa oriens, Schizocosa* sp.nov., *Trochosa musa* sp.nov., *Wadicosa fidelis, Pholcus fragillimus, Chrysilla stipesa* sp. nov., *Myrmarachne sp., Dictis* sp. nov., *Scytodes* sp., *Rhomphaea ceraosus, Uloborus walckenaerius, Heliconilla* sp. nov. and a one new genus and species from the family Zodariidae. Male of *Cyclosa moonduensis* was recorded for the first time from India.

INTRODUCTION

Spiders are generalist predators that can function as biological control agents within agroecosystems (Moulder and Reichle, 1972; Nyffeler and Benz, 1987; Riechert and Bishop, 1990; Young and Edwards, 1990; Kajak *et al.*, 1991; Kajak, 1997).

Most of the spider diversity in agro-ecosystem is studied by several researchers in rice fields from different states of India (Sellammal and Chelliah, 1982; Krishnaswami *et al.*, 1984; Gupta *et al.*, 1986; Rajendran, 1987; Nirmala, 1990; Ansari and Pawar, 1992; Banerji *et al.* (1993); Mishra and Shrivastava, 1993; Kumar, 1994; Thakur *et al.*, 1995; Ganeshkumar and Velusamy, 1996; Sahu, *et al.*, 1996; Samiyyan and Chandrasekaran, 1998; Venkateshalu *et al*., 1998; Anbalagan and Narayanaswamy, 1999; Pathak and Saha, 1999; Bhattacharya, 2000; Vanitha, 2000; Mathirajan, 2001; Shenhmar *et al.*, 2001; Zhimomi *et al*., 2001; Jose, *et al.*, 2002; Satpathi, 2004; Patel *et al.*, 2004 and 2005; Sebastian *et al*., 2005; Sudhikumar, *et al.*, 2005; Devarassou and Adiroubane, 2006; Diraviam *et al*., 2006; Kumar and Shivakumar, 2006; Manisegaran *et al*., 2006; Manu and Bai, 2006; Venturino, *et al.*, 2008; Chatterjee, *et al.*, 2009 and Jayakumar and Sankari, 2010). Recently,

Jeyaparvathi *et al.* (2013) also investigated the biological control potential of spiders on the selected cotton pests and found that the four species of spiders like (*Peucetia viridana Oxyopes birmanicus* (Thorell) and *Peucetia latikae* were predominant in the cotton fields of Achamthavirthan, Virudhunagar district, Tamil Nadu, India.

Siliwal Manju and Dolly Kumar (2002, 2003a,b) reported *Harmochirus brachiatus (Thorell), Dinopis goalparaensis*, *Triaeris manii* and *Triaeris poonaensis* spiders from banana agroecosystems of Baroda, Gujarat. Similarly they have also sighted *Latrodectus hasseltii indicus* Simon (Araneae: Theridiidae) in a cotton field in Baroda district, Gujarat during 2001. Harrison (1968) studied vertical distribution of spiders in the banana field from Panama. Members of family Argiopidae represented by largest number. Ntonifor *et al*. (2012) in their study observed *H. venatoria* inhabiting the soil litter /mulches, loose leaf sheats (barks) of pseudostems and stumps, leaf petioles, spaces between banana flower bracts and clusters.

However absolutely no work on the spider diversity in banana agro-ecosystem from, Maharashtra is reported earlier.

Absolutely no work on has been carried out on the spider diversity in agro-ecosystem from Vidarbha and Maharashtra.

METHODOLOGY

Sampling plots were selected in agriculture land along Purna Basin. Sampling plots (10 m ×10 m) for collection of spiders were selected randomly along two sides of Purna river basin agriculture land. 20 sampling plots in banana fields were sampled. Sampling was done by using pitfall traps and other semi quantitative collection methods. Sampling was carried out over three periods, winter (November – February), summer (March – June), Monsoon (July – October). Sampling of the spiders was carried out following different collection techniques *viz.* pitfall trapping and ground hand collection. The spiders were collected mostly during 7.30 am to 9.30 am. The average of data was then converted into per acre for calculations.

All adult specimens were identified up to family, genus and species level. Identification of spiders was done on the basis of morphometric characters of various body parts and the detail structure of epigyne of female and pedipalp of male spiders. A help of various keys and World Spider Catalogue (recent edition) and other relevant literatures from India and abroad was taken for proper identification. In case of difficulty, experts from other countries were also contacted by email for confirmation.

Initially the book, “Spider families of the world” by R. Jocque and A.S.Dippenaar-Schoeman was referred every time to identify the family of the spider and then to identify the genus and species, I used to go through the published Indian literature (Books and Monographs) first and then research papers from outside India.

Spider genera already known from India were compared first with the specimen under identification and if not matched then, many a times I used to refer the book, "Riceland spiders of south and south-east Asia" by Barrion and Litsinger (1995) for comparing the epigynal and pedipalp structures of spiders collected. Similarly, research papers from Asian Arachnologists were also reffered to compare the epigyne and pedipalp of spiders in question. World Spider Catalogue was useful to know the synonyms and transfers before finalizing the name of spider.

Voucher specimens are deposited at Arachnology Museum, Forest Training Institute, Chikhaldara.

While collecting the spiders, the actual place where the spiders was inhabiting was noted like on the ground, in the crevices, in mulch, on the foliage, on the trunk, pseudostems and in the web etc. The location of webs was noted like epigeal, basal, foliar etc.

Spiders captured by pitfall traps and hand picking methods were pooled for each site for quantitative analysis. Species richness was estimated using the diversity indices including Shannon – weiner index, Simpson index and Margalef richness index. The diversity and richness indices for spiders were calculated using the Biodiversity calculator (www. Alyoung.com/labs/biodiversity calculator. html). The R-squared values were calculated and Trendline was drawn with Excel for spiders from seven dominant families.

OBSERVATIONS AND RESULTS

50 species from 39 genera and 15 families were recorded during the present investigation (Table-1). By using visual search method and pitfall trap method in all 11880 spider specimens were collected per acre which includes 5792 (48.75%) females, 2696 (22.69%) male and 3392 (28.55%) immature individuals. Araneids dominated the collection with 3416 (28.75%) specimens per acre followed by Lycosids 3208 (27.00%), Sparassids 1688 (14.20%) and then Salticids 1200 (10.10%). The species abundance was in the order Araneidae > Salticidae > Lycosidae > Sparassidae (Fig.1). Salticids exhibited highest generic diversity followed by Araneidae and Lycosidae. Population of Araneids and Lycosids alone was more than 50% of the total population (Table-1). Males of *Argiope aemula, Argiope anasuja, Cyclosa bifida, Cyclosa purnai, Cyrtophora cicatrosa, Neoscona nautical, Lycosa poonaensis, Schizocosa* sp.nov., *Myrmarachne plataleoides, Scytodes* sp., *Olios millet, Olios punctipes, Parasteatoda mundula* were not observed during the survey. Banana fields were dominated by web builders, *Cyclosa moonduensis,*

Table: 1, Spider species collected (per acre) from Banana agro-ecosystem.

Spider species	Females	Males	Immatures	Total
Family Araneidae				
Argiope aemula (Walckenaer,1841)	64	0	624	3416
Argiope anasuja Thorell,1887	32	0		
Cyclosa bifida (Doleschall,1859)	432	0		
Cyclosa moonduensis Tikader,1963	328	488		
Cyclosa purnai sp. nov. Keswani,2013	32	0		
Cyclosa spirifera Simon,1889	48	24		
Cyrtophora cicatrosa (Stoliczka,1869)	16	0		
Cyrtophora citricola (Forsskål,1775) *	40	16		
Eriovixia excelsa (Simon,1889)	376	144		
Neoscona nautica (L. Koch,1875)	80	0		
Neoscona theisi (Walckenaer,1841)	104	16		
Neoscona vigilans (Blackwall,1865)	56	24		
Thelacantha brevispina (Doleschall,1857)*	256	216		
Family Clubionidae				
Clubiona foliata sp. nov.	72	48	32	152
Family Gnaphosidae				
Drassodes luridus (O. P.-Cambridge,1874)	24	16	48	232
Zelotes shantae Tikader,1982	88	56		
Family Lycosidae				
Hippasa greenalliae (Blackwall,1867)	224	16	632	3208
*Lycosa poonaensis*Tikader & Malhotra,1980	224	0		
Pardosa oriens (Chamberlin,1924)	360	184		
Pardosa pseudoannulata (Bösenberg & Strand,1906)	464	296		
Schizocosa sp.nov.	72	0		
Trochosa musa sp.nov.	256	152		
Wadicosa fidelis (O. P. Cambridge,1872) *	296	32		

.....continued

Spider species	Females	Males	Immatures	Total
Family Miturgidae				
Cheiracanthium inornatum	104	40	72	216
O. P.-Cambridge,1874				
Family Oxyopidae				
Oxyopes pankaji Gajbe & Gajbe,2000	24	16	8	48
Crossopriza lyoni (Blackwall,1867)	48	48	56	280
Family Pholcidae C. L. Koch,1850				
Pholcus fragillimus Strand,1907	112	16		
Family Pissauridae				
Nilus phipsoni(F. O. P.-Cambridge,1898)	40	8	16	64
Family Salticidae				
Chrysilla stipesa sp. nov.	16	16	240	1200
Hasarius adansoni (Audouin,1826) *	40	288		
Myrmarachne plataleoides	0	8		
(O. P.-Cambridge,1869)				
Myrmarachne sp	16	8		
Phintella vittata (C. L. Koch,1846)	88	40		
Plexippus paykulli (Audouin,1826) *	176	112		
Pseudicius ludhianaensis (Tikader,1974)	8	8		
Telamonia dimidiata (Simon,1899)	88	16		
Thyene imperialis (Rossi,1846) *	16	16		
Family Scytodiidae				
Dictis sp. nov.	8	8	16	88
Scytodes sp.	56	0		
Family Sparassidae				
Heteropoda bhaikakai Patel & Patel,1973	152	48	1384	1688
Olios milleti (Pocock,1901)	0	0		
Olios obesulus (Pocock,1901)	8	16		
Olios punctipes Simon,1884	80	0		

Spider species	Females	Males	Immatures	Total
Family Tetragnathidae				
Leucauge decorata (Blackwall,1864)	264	48	136	448
Family Theridiidae				
Parasteatoda mundula (L. Koch,1872)	32	0	16	88
Rhomphaea ceraosus (Zhu & Song,1991)	24	16		
Family Uloboridae				
Uloborus walckenaerius Latreille,1806 *	416	168	112	720
Zosis geniculata (Olivier,1789) *	16	8		
Family Zodariidae				
Heliconilla sp. nov.	16	8	0	32
sp. nov	0	8		

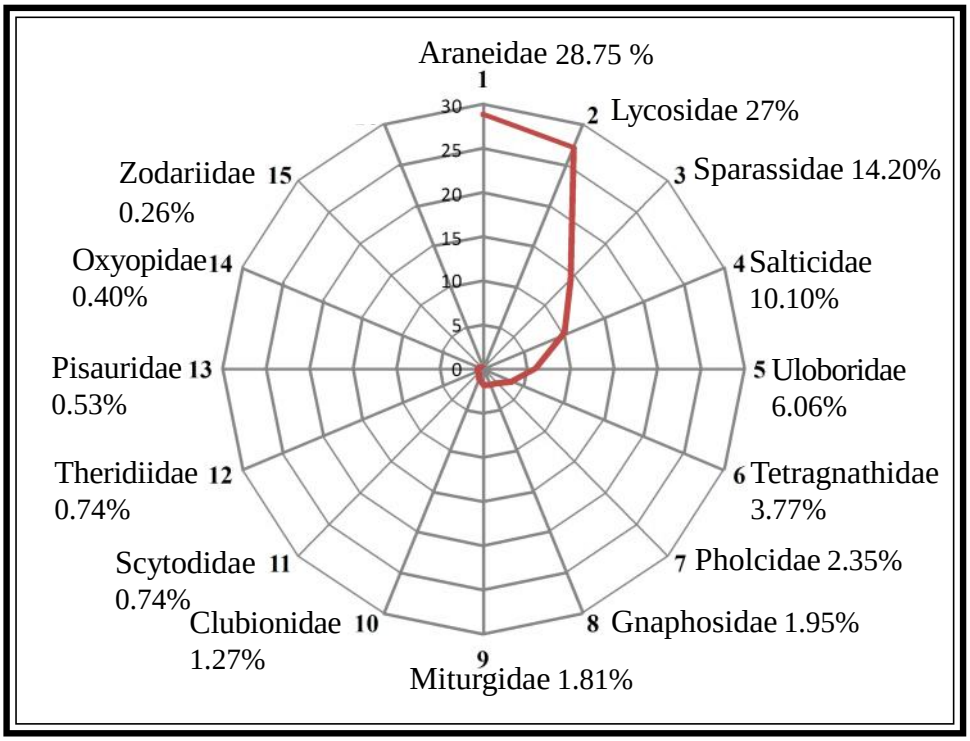

Fig. 1, Familywise percent occurrence of spider population per acre of Banana agro-ecosystem

Table-2, Microhabitat used by spiders in bnana agro-ecosystem

Species	Microhabitat used by spiders in Banana field
Argiope aemula (Walckenaer,1841)	In sunny areas resting on web between two banana plants, in grasses
Argiope anasuja Thorell,1887	In sunny areas resting on web between two banana plants, in grasses
Cyclosa bifida (Doleschall,1859)	On the web nearer to the the ground, in mulch
Cyclosa moonduensis Tikader,1963	On the web nearer to the the ground, in mulch
Cyclosa purnai Keswani,2013	Between the pseudostems, petioles and hanging leaves
Cyclosa spirifera Simon,1889	Between the pseudostems, petioles and hanging leaves
Cyrtophora cicatrosa (Stoliczka,1869)	Below the cluster
Cyrtophora citricola (Forsskål,1775)*	In the web between pseudostems nearer to the ground
Eriovixia excelsa (Simon,1889)	Between two banana plants, spaces between chopped pseudostems, fallen dried leaves and hanging leaves
Neoscona nautica (L. Koch,1875)	On the petiole
Neoscona theisi (Walckenaer,1841)	In the grass, between leaves, petioles and pseudostems
Neoscona vigilans (Blackwall,1865)	On the petiole, inside dried folded leaves

Thelacantha brevispina (Doleschall,1857)*	Between two banana plants, between the uppermost leaves
Clubiona foliata sp. nov.	Rolled up leaves, on foliage, under dead leaves, during day time in retreat in convoluted leaves
Drassodes luridus(O. P.-Cambridge,1874)	On ground surface, in leaf litter, under mulch
Zelotes shantae Tikader,1982	Ground
***Hippasa* greenalliae** (Blackwall,1867)	At the base of pseudostems in sheet webs provided with a funnel
Lycosa poonaensis Tikader & Malhotra,1980	On the ground, among the mulch, in leaf litter, in ground crevices
Pardosa oriens (Chamberlin,1924)	On the ground, among the mulch, in leaf litter, in ground crevices
Pardosa pseudoannulata (Bösenberg & Strand,1906)	On the ground, among the mulch, in leaf litter, in ground crevices
Schizocosa sp. nov.	Ground
Trochosa musa sp.nov.	On the ground, among the mulch, in leaf litter, in ground crevices
Wadicosa fidelis (O. P. Cambridge,1872) *	On the ground, among the mulch, in leaf litter, in the crevices
***Cheiracanthium* inornatum** O. P.-Cambridge,1874	On foliage, under leaf litter
Oxyopes pankaji Gajbe & Gajbe,2000	On foliage, ground
Crossopriza lyoni (Blackwall,1867)	Under older dried hanging leaves

Pholcus fragillimus Strand,1907	Older hanging leaves, spaces between the tiers, between chopped pseudostems
Nilus phipsoni (F. O. P.-Cambridge,1898)	On the edges of water supply pipe line
Chrysilla stipesa sp. nov.	On pseudostems, on leaves, in grasses
Hasarius adansoni (Audouin,1826) *	In mulch, on leaves, on pseudostems, loose leaf sheaths, on ground
Myrmarachne plataleoides (O. P.-Cambridge,1869)	On pseudostems
Myrmarachne sp.	On pseudostems
Phintella vittata (C. L. Koch,1846)	On pseudostems, on the leaves, in leaf litter, in mulch, under the leaves
Plexippus paykulli (Audouin,1826) *	In mulch, beneath loose leaf sheath, leaf petioles, on foliage
Pseudicius ludhianaensis (Tikader,1974)	On pseudostems, in mulch, in grasses
Telamonia dimidiata (Simon,1899)	On leaves, pseudostems, inside petioles
Thyene imperialis (Rossi,1846) *	On leaf surface, in mulch
Dictis sp. nov.	Under the dried leaves, ground, loose leaf sheaths
Scytodes sp.	Under the older folded leaves, loose leaf sheaths, on the ground
Heteropoda bhaikakai Patel & Patel,1973	On the ground, in decaying mulch, leaf litter
Olios milleti (Pocock,1901)	On foliage
Olios obesulus (Pocock,1901)	On foliage

Olios punctipes Simon,1884	In grasses, on the ground, in decaying mulch
Leucauge decorata (Blackwall,1864)	On web between corms, pseudostems and spaces between chopped stems
Parasteatoda mundula (L. Koch,1872)	Inside dried rolled leaf entangled in the web spun between pseudostems
Rhomphaea ceraosus (Zhu & Song,1991)	Spaces between banana flower bracts, tiers and fingers of bunches
Uloborus walckenaerius Latreille,1806 *	Spaces between clusters and fingers of the bunch, below the bunch, underside of the leaves, on pseudostems
Zosis geniculata (Olivier,1789) *	In the dark areas below the dense hanging leaves
Heliconilla sp. nov.	On ground
sp. nov.	On the ground

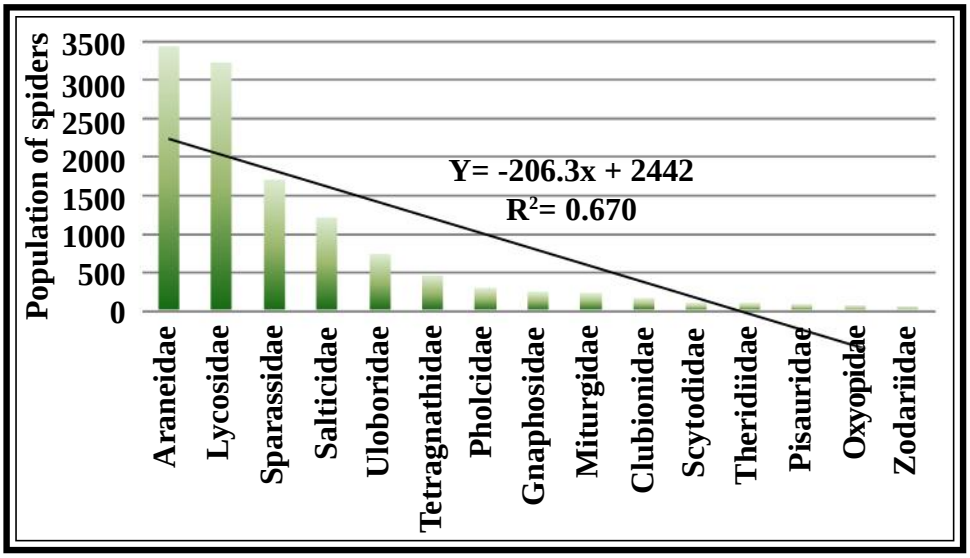

Fig. 2, Trendline and Coefficient of Determination (R^2) for the occurrence of spiders in the banana agro-ecosystem from Purna river basisn.

Eriovixia excelsa, Thelacantha brevispina, Leucauge decorata, Uloborus walckenaerius. While among hunters *Pardosa oriens, Pardosa pseudoannulata, Trochosa musa* sp.nov., *Plexippus paykulli, Heteropoda bhaikakai* were predominantly observed.

15 new species were recorded from Banana agroecosystem which includes *Cyclosa purnai* sp. nov., *Clubiona foliata* sp. nov., *Pardosa oriens, Schizocosa* sp.nov., *Trochosa musa* sp.nov., *Wadicosa fidelis, Pholcus fragillimus, Chrysilla stipesa* sp. nov., *Myrmarachne sp., Dictis* sp. nov., *Scytodes* sp., *Rhomphaea ceraosus, Uloborus walckenaerius, Heliconilla* sp. nov. and a one new genus and species from the family Zodariidae. Male of *Cyclosa moonduensis* was recorded for the first time from India.

Population of Oxyopids and Tetragnathids was negligible in banana agro-ecosystem and Thomisids were not observed (Table-1).

During survey and collection of spiders, the microhabitats used by them were noted and accordingly the detail observations are given in table-2. Categorically, three types of major microhabitats were noted, in the web, on the plant / branches and on the ground. Among web builders also, webs were found to be constructed on the ground (epigeal), between ground and plant (basal) and between adjacent plants and branches (folier). Hunting spiders were seen using microhabitats like mulch and litter on the ground, crevices in the ground, on the ground surface, foliage, on the plants and pseudostems, dried leaves etc.

The spiders in banana agro-ecosystems are observed preying upon insect pests from orders Lepidoptera, Diptera, Homoptera, Coleoptera, Hymenoptera, and Orthoptera. The orb-weavers Araneidae and Tetragnathidae were observed feeding upon Homoptera such as leafhoppers, Diptera and Orthoptera, especially grasshoppers. The smaller sheet web-weavers such as Theridiidae were seen capturing insects from Diptera, Hemiptera and Homoptera (especially aphids and leafhoppers). The funnel web spider, *Hippasa* and the social spider *Stegodaephus sarasinorum* were seen preying upon Orthopterans, Coleopterans and Lepidopterans. Hunting spiders (Lycosidae, Oxyopidae and Salticidae) frequently were observed preying upon species from Orthoptera, Homoptera, Hemiptera, Lepidoptera, Thysanoptera, Diptera and some Coleoptera and Hymenoptera. Spiders in banana agroecosystem under study were observed feeding on pests like *Cosmopolites*

sordidus (Root borer), *Odoiporus longicollis* (pseudostem weevil), *Pentalonia nigronervosa* (aphid), *Thrips hawaiiensis* (thrip), *Tiracola plagiata* (Lepidoptera), *Chaetanaphothrips signipennis* (rust thrips), *Nacoleia octasema* (scab moth) etc.

Coefficient of determination was calculated as R^2= 0.670 and the trendline drawn exhibited the equation Y= -206.3x + 2442. Dominance Index, Shannon Index and Margalef Richness Index were calculated and were 0.9045, 4.812 and 5.416 respectively.

DISCUSSION

Banana agro-ecosystem was found to be dominated by *Cyclosa moonduensis* Tikader, 1963. Astonishingly, the spider *Thelacantha brevispina* was found in banana fields with a good population. The second important aspect is this spider secretes green egg sac silk. Another important genus is *Pardosa* which is dominating the Banana fields. In banana the ground is almost covered with big leaves and hence the ecosystem is humid. Further, the ground surface is covered over with decaying mulch which forms a good microhabitat and hiding places for Lycosids and sparassids and hence the population of the spider of these two families is more in Banana fields. Ntonifor *et al*. (2012) also reported *Heteropoda venatoria* inhabiting the mulches in Banana fields from Cameroon. However, in the present survey, in addition to *H. bhaikakai*, three species of *Olios* Walckenaer, 1837 were also observed inhabiting the same habitat. All these spiders are with high fecundity and are voracious feeders. Another important spider endemic to Banana fields and with high fecundity is *Nilus phipsoni*. In the present study, large number (1384 per acre) of subadults/immature Sparassids were observed showing their survival in the agro-ecosystem. Banana plant architecture and the Banana agro-ecosystem offer a suitable habitat with respect to prey availability, hiding places, crevices, banana clusters, tubular leaf stalks, pseudostem, leaf sheaths, spaces between flower bracts, etc., therefore spider like *H. bhaikakai* and *Olios milleti* prefer this ecosystem. Their juveniles show delayed dispersal. The delay in juvenile dispersal is beneficial for pest control. The color of *H. bhaikakai* and *Olios milleti* also matches with that of pseudostem, leaves and hence these spiders can camouflage better with the background.

In the present investigation Banana field exhibited very high dominance index (0.9045). This could be because of the proper environmental parameters like, humidity, water and enough number of pests of choice might have been available to these spider species. Another reason may be the duration of the crop. The banana crop is of 1.5 years and hence these spiders might be getting favorable ecosystem for a longer time till the youngones are hatched and developed further.

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